the best brands of wrought iron, which contain about 99.5 per cent of iron, against 84 per cent in the manganese steel.

Electrical Properties.

This material possesses the peculiar property of being almost entirely non-magnetic. Rinman mentioned in 1773 that manganese diminishes, and in the end destroys, the magnetic properties of iron. This was also noticed in some specimens of manganese alloys made by Mr. David Mushet about 1830. This is especially curious, seeing that iron is present in amounts eight or nine times greater than the manganese itself. An approximate idea of the amount of manganese contained in the steel may be formed by passing a magnet over specimens. As the percentage of manganese increases, the magnet's power decreases. Upon reaching about 8 per cent, there is no attraction in the bulk, though fine drillings are influenced; but even this diminishes, as, when 20 per cent is reached, a magnet capable of lifting 30 pounds of ordinary steel or iron will only lift pieces weighing a few milligrams. On this point the material behaves in the same manner either in its forged or cast state, water or oil quenching making practically no difference.

Some interesting experiments with regard to the physical properties of manganese steel have been made by Sir William Thomson, Mr. Bottomley of Glasgow, and Professor Reinold of the Royal Naval College, Greenwich. Prof. W. F. Barrett, of the Royal College of Science, Dublin, has also experimented respecting its non-magnetic character and electrical properties. His experiments were carried out upon a sample containing, carbon, .85 per cent; manganese, 13.75 per cent; the wire being drawn to No. 19 British wire gauge. The author first attempted to draw direct from the rods, but with little progress; the wire, owing to its hardness, breaking into short lengths when being pulled through the wortles. Ordinary annealing was tried, but with no better results. As exceedingly good bending tests have been obtained with bars from the same steel, when heated to a yellow heat and plunged into cold water, the rods were treated in the same manner. These were coiled up, heated to whiteness, and plunged into cold water. The material was then easily drawn; but, after every reduction through two sizes, its ductility was again lost, and the operation of heating to whiteness and quenching in cold water was again necessary. A specimen has been subjected to white heat no less than five times, and is yet uninjured, as will be seen from the remarkable tensile tests obtained from it by Professor Barrett, viz., 110 tons per square inch, in its hard state. A similar result was obtained by the manager of the wire department at the Barrow Steel Works, the report being "that it would stand any tensile load up to 100 tons per square inch, according to the temper, and the elongation was extraordinary." The density, according to Professor Barrett, was 7.81, which is somewhat lower compared with the specific gravity obtained at the Hecla laboratory; viz., 7.83 on the same wire. The electric conductivity was found to be very low; No. 19 British wire gauge wire, .96 millimetre in diameter, having a resistance of 1.112 legal ohms per metre, or 75 microhms per cubic centimetre at 15° C. Ordinary iron wire is only 9,800, and German-silver 21,170; so that use might be made of the manganese steel for resistance-coils in electric-lighting. This has since been successfully applied by Dr. E. Hopkinson, in Messrs. Mather & Platt's electric department. Its high specific resistance, and capacity to stand heating, make it very useful for resistance-boxes. A length of 1,180 yards No. 8 British wire gauge (No. 634, manganese 13.95 per cent) was cut into three lengths, coupled parallel, the conductor consisting of three strands No. 8, then coiled into a box 3 feet by 2 feet by 2 feet, and gave a resistance of 6.5 ohms, carrying 80 ampères without over-heating. It was therefore capable of absorbing 55-horse power. To produce the same resistance with iron wire, 5,000 to 8,000 yards would be required, or, of expensive German-silver wire, 4,780 yards. Professor Barrett also finds that its increase when heated is only .136 per cent for each degree carbon, as against iron .5 per cent.

In the same way it is a bad conductor of heat. A rough test was made at the Hecla works by putting a bar of this material and one of ordinary wrought iron into a smith's fire. The latter became too hot to handle in about half the time required for the former. From this will be seen the importance of thoroughly 'soaking' this steel when forging it, or the outside only may be heated.

As regards its non-magnetic properties, a small piece of the No. 552 wire was not attracted in the slightest degree by the most powerful electro-magnet capable of lifting a ton; but, suspended by a thread, it behaved like a paramagnetic body. Professor Reinold found that the water-quenched or softened wire acquired slightly more permanent magnetism, but that with both a most sensitive galvanometer-needle was required to show that the material was not copper or other non-magnetic body. The exact amount was determined by Professor Barrett after most careful experiments. In comparing this with ordinary steel, he states that it was like weighing hundredweights and grains on the same balance. The magnetism of ordinary iron being represented by the figure 100,000, manganese steel is 20, and its susceptibility, i.e., the induced magnetization, is about as low as zinc or other non-magnetic metal. It is somewhat extraordinary to find no sensible attraction exerted on this steel by the most powerful magnetic field that could be obtained, this agreeing with Dr. Hopkinson's experiments. If other difficulties can be overcome, this peculiar quality should make it suitable for dynamo bed-plates. Ships built of such steel would have no sensible deviation of the compass. Magnetic influence, while not affecting this material, passes through it, so that a needle placed upon a flat sheet of manganese steel can be readily moved by a magnet placed underneath. The same thing occurs if brass or sheet copper be substituted, but not with ordinary steel or iron.

Further interesting experiments have also been lately made (September, 1887) by Profs. J. A. Ewing and William Low. The former concludes his experiments by stating, that, even under magnetic forces extending to 10,000 C.G.S. units, the resistance which this manganese steel offers to being magnetized suffers no change in any way comparable to that which occurs in wrought iron, cast iron, or ordinary steel, at a very early stage in the magnetizing process. On the contrary, the permeability is approximately constant under large and small forces, and may be therefore concluded as being only fractionally greater than that of copper, brass, or air.

MUSICAL BOXES.

MUSIC, both as a science and an art, has reached a stage of development so far advanced that further improvement in any department must necessarily seem slow and insignificant. Yet improvements are being made in many directions, seemingly small, but really great enough to demand more than a passing notice.

A good instrument is, of course, necessary to the production of

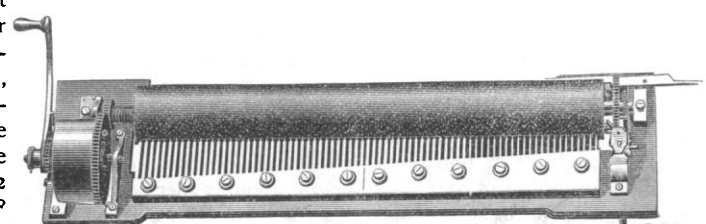

FIG. 1.

good music; but upon even the best of such instruments as the violin or piano, for instance, good music cannot be produced without the aid of a good musician. Of musicians, as musicians go, there are plenty, — ordinary every-day musicians, not born to the art, but bred to the business, working at music as a trade, not as an art; but of good musicians, with a heritage of genius supplemented by a lifetime of labor spent in study, there are few.

Most people are lovers of good music, or at least of melodious and harmonious sounds. Among these are many who are not musicians themselves, and by whom the services of a good musician are not at all times procurable, nor perhaps desirable. There is but one among the innumerable instruments in vogue to-day to which such persons can turn, — an instrument in which more or less successful attempts have been made to combine not only the parts to be played upon, perfect of their kind, but also as close an approximation to the executive talents of a musician as mechanical skill will give. This instrument is known as the musical box, not the crude mechanism of a few decades ago, but the improved instrument of to-day.

Musical boxes, properly so called, were invented about the beginning of the present century, and were at first exceedingly imperfect and costly. Since that time numberless improvements have been made, notably by members of the Paillard family, of Ste.

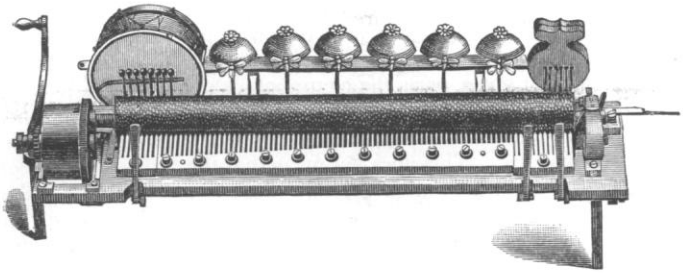

FIG. 2.

Croix, Switzerland, at which place they have been engaged in the manufacture of these instruments since 1814. Many of the musical boxes, as now made by this house and exhibited in New York, have attachments which bring into play various devices, such as bells, drums, and castanets, for adding to the general effect. There are

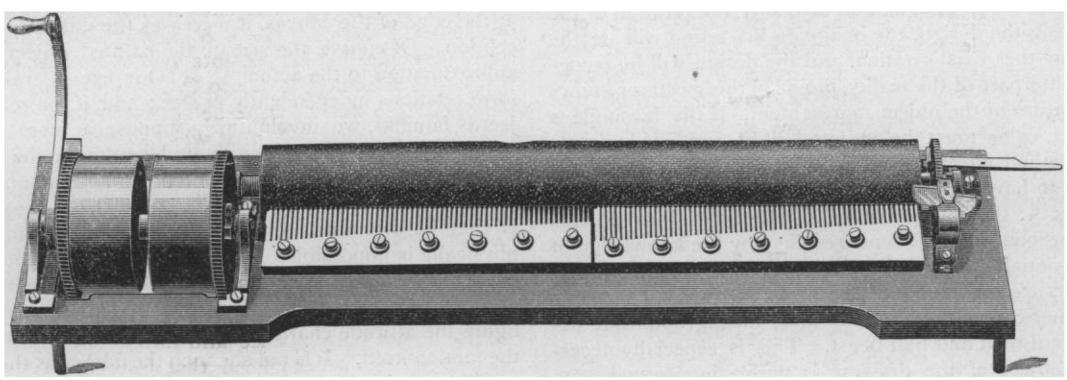

FIG. 4.

also what are known as the 'mandoline or tremolo harp-zither' attachment, 'sublime harmonie,' 'zither harmonique piccolo and tremolo,' and 'orchestra.' These boxes are furnished with one, two, or four springs, and single, duplex, or interchangeable cylinders.

At Fig. 1 is shown the cylinder, comb, and spring-barrel of an

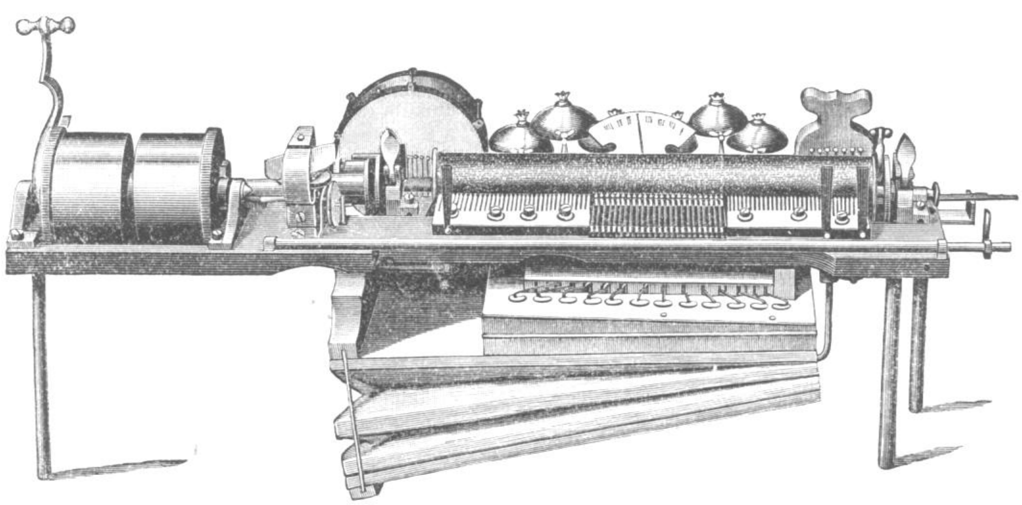

FIG. 5.

ordinary musical box. The winding-lever stands at the extreme left, and the small fan-shaped governor for regulating the speed may be seen at the right. Fig. 2 shows the works of a box with drum, bells, and castanets. These attachments may be silenced separately or together. Fig. 3 shows works with thirty-minute coupled springs and mandoline or tremolo harp-zither attachment. The characteristic feature of this box is that the same note is repeated consecutively, as is done on the harp, guitar, or piano.

An instrument with coupled springs and double comb or keyboard, giving a much louder and fuller tone, is shown at Fig. 4. An improvement on the coupled springs is shown at Fig. 6. It consists of a combination of four springs, enabling the instrument

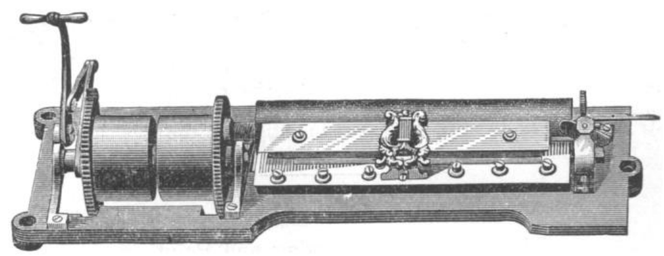

FIG. 3.

to run one or two hours with one winding. The orchestral musical box, the mechanism of which is shown at Fig. 5, has, besides the devices already mentioned, a flute or 'celestial voice' attachment, consisting of reeds placed in the centre of the keyboard, and vibrated by air from the bellows underneath the bed-plate.

One of the recent improvements in these instruments is what is called the 'interchangeable cylinder' system, the advantage of which is that additional cylinders may be obtained at any time, ready for immediate use, without the necessity of sending the box to the factory to have them fitted. This is an adaptation of the interchangeable system so much in vogue in the manufacture of sewing-machines, type-writers, and similar articles.

Few persons have any idea of the extent and importance of the

trade in musical boxes, but a visit to the establishment of M. J. Paillard will convince the most sceptical that automatic musical in-

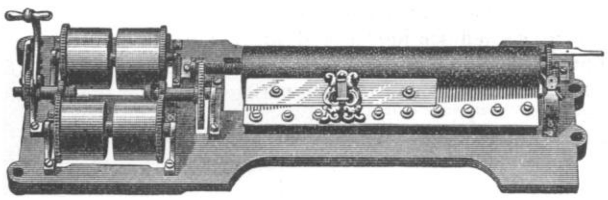

FIG. 6.

struments play an important part in satisfying the musical demands of the public.

MENTAL SCIENCE.

The Illusions of Drawing and Painting.[1]

THE arts of drawing and painting depend upon the possibility of presenting to the eye a result in two dimensions of space which it will readily transform into one of three dimensions. In this process there is a large element of illusion — of conscious, designed illusion. The chief factor in this process is perspective. If the spectator take, whether in imagination or reality, the position of the artist when making the design, the image on his retina will be the same as that on the artist's retina, and the design will be recognized as the counterpart of the reality, provided the spectator knows in general the nature of the object represented. If the facsimile is to be more exact, color must be imitated, light and shade introduced, and the retinal effect copied with all the skill of eye and hand. In order to have an æsthetic effect, the picture must represent known objects : the interpretation of two-dimensional objects into three-dimensional must be rendered easy by the knowledge of the three-dimensional. The artist must not create entirely new forms : exceptions are apparent only, and prove the rule. The poetic monsters are either conventionalized, or unite incongruous but existing forms, — half man and half beast. This is especially necessary when the object of the drawing is purely intellectual, — to make clear something not easily expressed in words, such as designs for houses, mechanical constructions, and the like. Here a more or less exact knowledge of the type of object represented is needed. To the layman such designs have little meaning.

In artistic painting, however, it is not the most detailed and exact drawing that produces the best result. Photography excels all manual art in this, but its effect is of a lower order. The same can be said of those clever productions by which a bas-relief appears drawn in two dimensions, or the objects of a panorama to stand out in three. One admires the skill, but it is a curiosity rather than a piece of art. But the object of art is not servile imitation, not to give the spectator an absolute illusion, but to arouse certain feelings, certain thoughts ; and those details must be chosen that bring to mind the appropriate sentiments.

The spectator of a painting never loses entirely the sense of viewing a painted surface : for (1) the drawing is strictly accurate only for one point of view ; every change of position vitiates the perspective ; (2) the phenomena of binocular vision prevent the illusion (the points of the canvas are seen at the real distance of the eye from the canvas, and not at the various distances required by the perspective ; while, furthermore, the real object would form different images on the two retinæ, and the painting gives two nearly alike) ; (3) even in viewing objects monocularly, we get impressions of distance, for the eye constantly moves, while these changes are quite different in viewing a painting with one eye (the illusion of a painting is no doubt increased by regarding it monocularly through a hollow tube) ; (4) color and light can be imitated, but their mental effect is recognizably different from that of the real objects.

A picture placed in a horizontal position produces the illusion nearly as well as in a vertical position. If it be a marine view, the water does not seem vertical in the former case, though in the latter it seems horizontal. If it be an architectural design, it is not displaced, any more than we confuse directions when we gaze at an object in a reclining position. This is the result of much practice in seeing the form of representations irrespective of their position, and in transforming the actual retinal image into the one that the artist intends. If you dispense with all light and shade, with all color, with all perspective, and leave simply a bare outline, then we can see in such an outline all the various designs which it can physically represent. If you draw one square within another and join the corners, you can see such a figure either as the description just given, or as the picture of a shallow trough looking into the bottom, or as a view of the same object from the bottom ; and so on. Light and shade, familiarity with the design, decide what we shall see. This does not mean that the artist may neglect perspective, but only that the object of the perspective is to make easy the mental apperception of the spectator. Cases occur in which a painter violates the rules of perspective, if by following them he would produce a scientifically accurate but apparently unnatural result.

In the perception of distance the objects touching the lower edge of the canvas are, as a rule, meant to be seen as in the plane of the canvas. This gives the spectator his point of view, while the framing of the picture by supplying a vertical and a horizontal, aids very materially his conception of position. If in a landscape we have the ground touching the lower end of the canvas, and the sky the upper, we can judge distances best. If a prominent object is cut at the edge of the canvas, it increases the difficulty of distance perception. Of course, the size of the painted objects need bear no approximation to the actual size. Our eye is trained to perceive form relations independently of size ; and, if the real size of the object is familiar, we involuntarily suppose a more distant point of view. So, again, we generally underestimate the size of colossal figures, because we allow too much for our distance from them.

A more complete proof that imitation is not the artist's chief aim is that he attempts to represent motion in a single view, which physically is impossible. When a tree is represented in a wind, its branches are shown bent and strained in the direction of the wind ; and this gives us at once the picture of a wind, of motion. So in a figure the attitude characteristic of a series of motions stands for the motion itself. It is not so much the fidelity as the suggestiveness of the attitude that is important. So, again, when objects move very rapidly, they become indistinct to our vision, and by painting them as indistinct the illusion of rapid motion is aided. If the motion is too rapid for the eye to follow, as in the rotation of the spokes of a carriage-wheel, the peculiar appearance can be imitated on canvas, and suggests extreme speed.

In the walk or run of an animal, although one position follows another with great rapidity, the eye selects certain positions as typical, and these the artist uses as the presentation of movement. Generally the position at the beginning or the end of a step is chosen. Instantaneous photography shows the great variety of positions in passing from one step to another ; but many of these have an unnatural appearance to the eye, and the artist cannot utilize them.

A very distinctive illusion is shown in many portraits in which the eyes seem to follow the eyes of the spectator. This occurs when the model's eyes are facing the artist's. We assume the position of the artist, and so have the eyes in the picture looking at ours. If we move to one side, we get the illusion of the portrait's turning about, because the eyes still suggest direct vision, and the rest of the pose does not strongly contradict it. This lateral displacement, brought about by a change of position, is very slight in a painting, while very marked in a three-dimensional object. Paintings of animals frequently show similar effects. The true artist must understand and utilize such illusions, for they make the difference between what is lifelike and what is artificial.

[1] By M. J. L. Soret, in *Revue Scientifique*, Nov. 3, 1888.

THE HOMING INSTINCT. — Dr. George M. Gould (*Progress*, October, 1888) has collected authentic cases of animals finding their way homeward over long distances. Dogs, even when carried away in a blindfolded or drugged condition, find their way home over distances from five to five hundred miles ; and in one case, when the dog was taken off along the two sides of a triangle, he came home by the third side. The exquisitely trained instinct of the flying pigeon, and similar capabilities of most animals, show the